

The Comparison of the Swift Gamma-Ray Bursts With and Without Measured Redshifts

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Abstract.

Gamma-ray bursts, detected by the Swift satellite, are separated into two samples: the bursts with and without determined redshifts. These two samples are compared by the standard Student t-test and F-test. We have compared the dispersions and the mean values of the durations, peak fluxes and fluences in order to find any differences among these two samples. No essential differences were found.

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THE SAMPLE

We define two samples from the Swift dataset [1]: The sample of GRBs without measured redshift z (189 GRBs, 182 with measured duration T_{90}), and the sample with measured z (97 GRBs, 94 with measured T_{90}). We know the name of GRB, its BAT duration T_{90} , BAT fluence at range 15-150 keV, BAT peak flux at range 15-150 keV, and redshift. Total number of the GRB studied is 286. The sample covers the period November 2004 - December 2007; the first event is GRB041227, the last one is GRB071227.

COMPARISON OF THE PEAK FLUX

The first sample without measured redshift contains 186 GRBs with the mean value of the peak flux $2.7 \text{ ph}/(\text{cm}^2\text{s})$ and the dispersion $4.9 \text{ ph}/(\text{cm}^2\text{s})$. The second sample with measured redshift contains 95 GRBs, with the mean value of the peak flux $3.9 \text{ ph}/(\text{cm}^2\text{s})$ and the dispersion $6.3 \text{ ph}/(\text{cm}^2\text{s})$. The F-test for the dispersions tells $F = 1.66$ (it belongs to the critical interval $= \langle 1.29; \infty \rangle$), and thus the dispersions are not the same on the $\alpha = 5\%$ level of the significance, [2, 3]. The Student t-test for the mean values gives $t = 1.605$ (it does not belong to the critical interval $= \langle 1.645; \infty \rangle$), and then the mean values of the peak fluxes are the same on average, [2, 3]. See Fig. 1.

COMPARISON OF THE FLUENCE

The first sample without measured redshifts contains 188 GRBs, with the mean fluence $29.4 \times 10^{-7} \text{ erg}/\text{cm}^2$ with the dispersion $80.3 \times 10^{-7} \text{ erg}/\text{cm}^2$. The second sample

with measured redshifts contains 96 GRBs, with the mean peak flux $33.2 \times 10^{-7} \text{ erg}/\text{cm}^2$ with the dispersion $59.5 \times 10^{-7} \text{ erg}/\text{cm}^2$.

The F-test for the dispersions tells $F = 1.82$ (it belongs to the critical interval $= \langle 1.29; \infty \rangle$), hence the dispersions are not the same on average on the $\alpha = 5\%$ level of the significance, [2, 3]. The Student t-test for the mean values tells $t = -0.453$ (it does not belong to the critical interval $= \langle -\infty; -1.645 \rangle$) and then the mean fluences are the same on average [2, 3]. See Fig. 2.

COMPARISON OF THE DURATION T_{90}

Having dozens of GRBs with measured redshifts we can compare the two Swift samples with the standard F-test and Student t-test [2, 3], for the sample without (182 GRBs) measured redshifts one obtained: $\mu_1 = -0.73$ ($T_{90}(1) = 0.19\text{s}$), $\sigma_1 = 0.71$, $\mu_2 = 1.54$ ($T_{90}(2) = 34.67\text{s}$), $\sigma_2 = 0.56$, the rate "short GRBs : long GRBs" = 9 : 91 (in %, also absolutely 16 : 166); for the sample with (94 GRBs) measured redshifts one obtained: $\mu_1 = -0.46$ ($T_{90}(1) = 0.35\text{s}$), $\sigma_1 = 0.51$, $\mu_2 = 1.52$ ($T_{90}(2) = 33.11\text{s}$), $\sigma_2 = 0.62$, the rate "short GRBs : long GRBs" = 6 : 94 (in %, also absolutely 6 : 88).

We have tested the rates of the long GRBs in the both samples. The t-test tells $t = -0.871$ (it does not belong to the critical interval $= \langle -\infty; -1.645 \rangle$), hence the rates of the long GRBs (and the short ones as well) are the same on average [2, 3].

We have tested the dispersions with the F-test for the short GRBs. The $F = 1.938$ (it does not belong to the critical interval $= \langle 4.619; \infty \rangle$), the dispersions are the same on average. Then we have tested the mean T_{90} for the short GRBs. The t-test tells $t = -0.975$ (it does not belong to the critical interval $= \langle -\infty; -1.645 \rangle$), hence

Fig. 1: Duration vs. photon flux

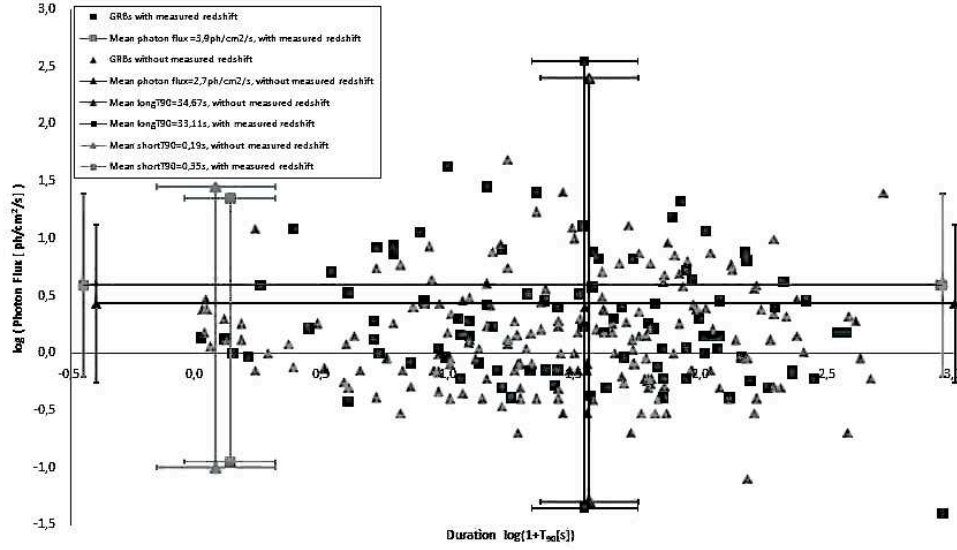
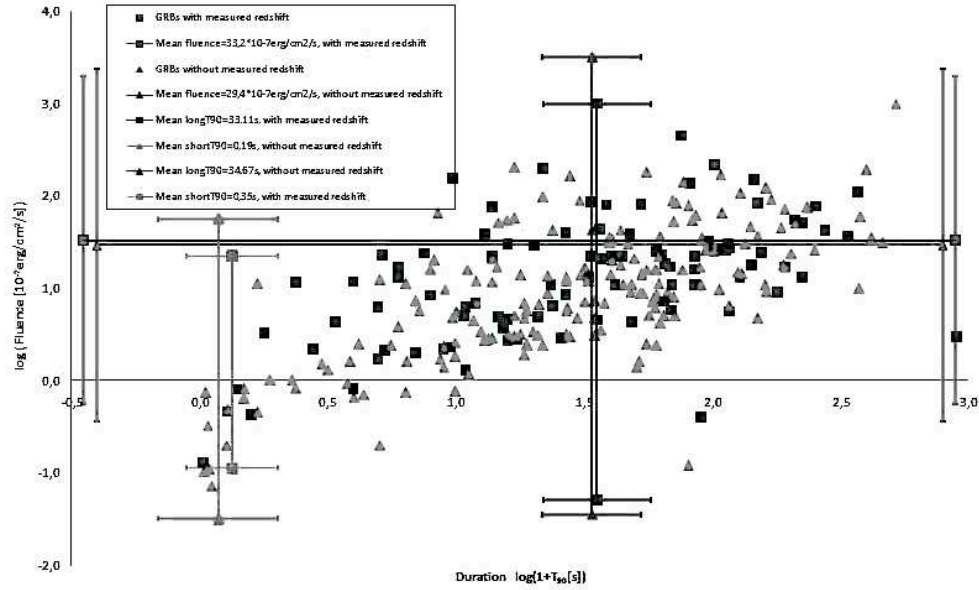


Fig. 2: Duration vs. fluence



the means are the same on average [2, 3]. We have tested the dispersions with the F-test for the long GRBs. The $F = 1.226$ (it does not belong to the critical interval $= \langle 1.439; \infty \rangle$), and thus the dispersions are the same on average. We have tested the mean T_{90} for the long GRBs. The t-test tells $t = 0.253$ (it does not belong to the critical interval $= \langle 1.645; \infty \rangle$), and then the means are the same on average [2, 3].

CONCLUSION

The Swift satellite detected 189 GRBs (about 2/3 of the whole sample) without measured redshifts and 97 GRBs (about 1/3 of the whole sample) with measured redshifts. We compared these two samples in the mean values of the duration, peak fluxes and fluences, respectively. We have used the F-test [2, 3] for comparison of their dispersions, and the Student t-test [2, 3] for comparison of their mean values. We have determined that the mean values of all characteristics of the Swift GRBs are the same on average at the $\alpha = 5\%$ level of the significance. But this is not the case for the dispersions. Hence, some differences exist in the two groups in accordance with [4], which can have an impact on the redshift distribution of GRBs [5, 6]. In our opinion the difference in the dispersions can be an instrumental effect, hence no essential difference is found between the two samples.

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